Pine Bark Physical Properties Influenced by Bark Source and Age©

Jeb S. Fields, Brian E. Jackson and William C. Fonteno
Department of Horticultural Science, North Carolina State University, Raleigh, North Carolina 27696, USA
Email: jsfields@vt.edu

INTRODUCTION

Bark has been an important component in horticultural mixes for years, and in the nursery industry, barks from several species are the most common substrate component used in the United States. Bark is obtained as a byproduct of the timber industry when it is striped off logs after harvest. After being removed from the logs it is stockpiled on site or shipped for many uses including as a fuel, mulch, or a horticultural substrate. The bark suppliers hammer-mill and screen the bark to obtain a desired particle size. Pine, fir, and redwood are the most common forms of bark used in the industry (Hanan, 1998). In the Southeast, loblolly or longleaf pine is most prominent due to the tree species' plentiful existence, rapid growth rate, and desirable physical properties attained from the bark. However, pine bark can vary in many properties depending on source and manufacturing process (Pokorny, 1975).

Most nursery growers have typically used aged bark. Aging is a modified composting process where the bark is piled on the ground in windrows, and allowed to age for a period of time. The bark is turned as needed in order to facilitate breakdown of the particles as well as reduce excessive heat buildup. Based on conversations with bark suppliers in North Carolina, industry demand for fresh bark (also known as green bark), has increased. Green bark tends to have more white wood, due to less time for breakdown during the aging process. White wood is a term used to describe the actual pine wood, or xylem, and not the bark that accompanies the bark during the debarking process. Freshly harvested bark also possesses a much higher amount of its naturally occurring waxes and acidic functional groups, than that of aged bark (Airhart et al., 1978). Demand for pine bark in other industries is also on the rise, primarily for use as a fuel source, thereby increasing competition for the product. Both fresh and aged pine bark have been shown to become hydrophobic when moisture content falls below 34% (Airhart et al., 1978).

As previously stated, as bark is aged, white wood is broken down. Therefore freshly harvested pine bark tends to have a higher percentage of white wood. As of today, no survey of white wood percentage in pine bark has been conducted to assess how much white wood is in bark supplies. In the past, white wood was considered to be undesirable by growers, however recent research (Jackson, 2010) showed that pine tree substrates can be used as a component with pine bark to produce nursery crops.

The duration of aging, pre-processing conditions, and manufacturing methods can alter bark physical properties (Bilderback, et al., 2005. The harvest date of the trees also plays a role in the variability of pine bark. Bark harvested in the colder months will be more uniform, while bark harvested in the spring months tends to be more varied. The amount of wood in bark also has to do with the harvest date (Solbraa, 1974). During the spring, the cambium of a pine tree is full of sap. When the bark is removed from a tree like this it tends to peel and stick together and pull out white wood. In colder months the cambium is not as sappy, resulting in more even sized nuggets and less white wood.

Self and Pounders (1974) showed that plants can be grown in fresh pine bark,; however aged pine bark has a more uniform and appropriate particle size distribution for plant growth (Pokorny, 1979). Studies have shown increased plant growth in aged bark as opposed to fresh bark (Harrelson et al., 2004; Laiche, 1974; Handreck and Black, 1994). However, this may be species dependent, as Cobb and Keever (1984) showed no difference in plant growth between plants grown in aged versus fresh bark.

MATERIALS AND METHODS

Pine Bark Acquisition and Sample Preparation

Pine bark was acquired from two suppliers in Eastern North Carolina. The two sources were large pine bark suppliers, which both process pine bark for use as a horticultural substrate, and are both readily available. Due to their relative close location, costs associated with transportation for growers would be similar when purchasing from either of these two suppliers. However these two suppliers differ in their processing methods, which could yield somewhat different products. Source 1 hammer-mills the entire shipment of raw pine bark upon arrival, and irrigates the windrows during the ageing process. Source 2 screens the shipment of raw pine bark and only uses the lowest screen for their horticultural substrate, and does not irrigate the bark piles during ageing.

Multiples samples were taken from several locations within a pile (Fig. 1). Samples were split in two with one subsample retaining its white wood, while the second subsample had all visually identifiable white wood removed. The two sources with two ages, each with and without white wood yielded eight treatments.

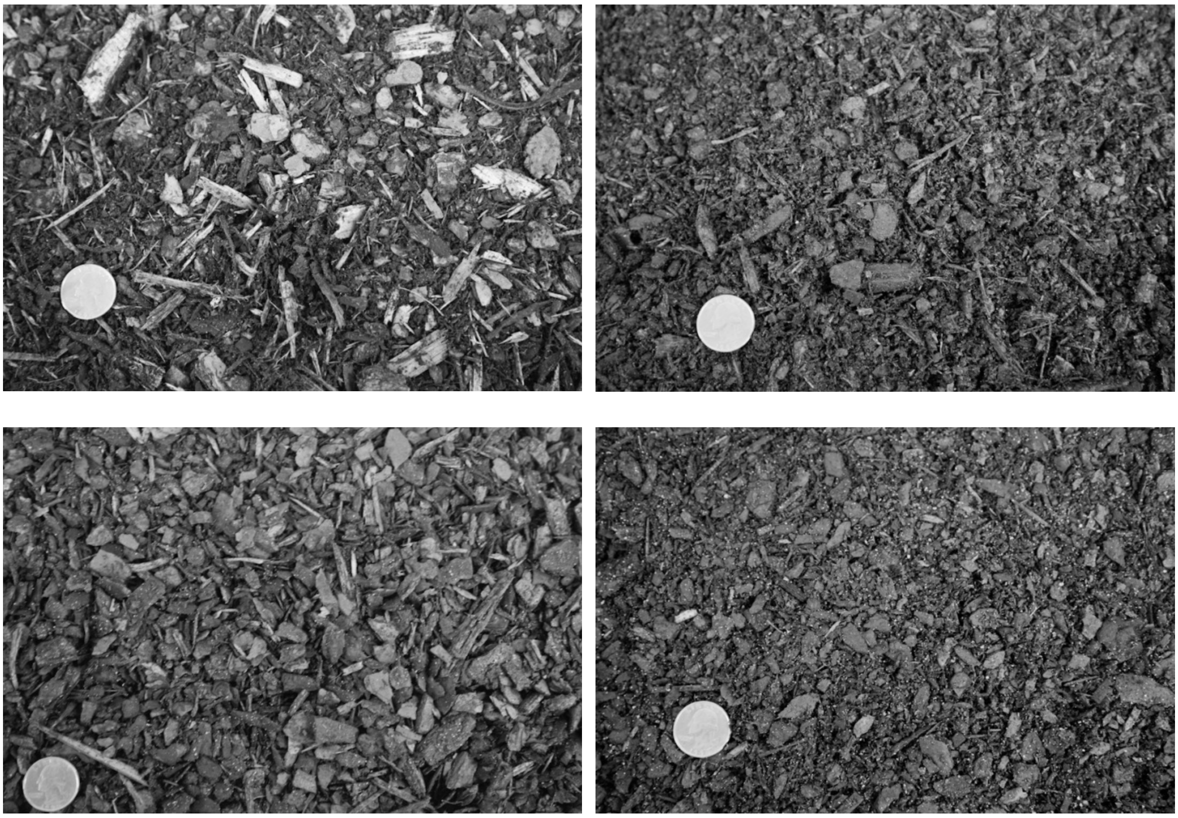

Fig. 1. Photographs of four bark samples tested for physical properties. Top right is Source 1 fresh, top left is Source 1 aged, bottom right is Source 2 fresh, and bottom left is Source 2 aged.

Particle Size Distribution (PSD)

Three samples of 100 g per treatment were dried for 48 h in a forced air oven at 105°C, and then shaken at 160 shakes per min. through U.S.A. standard sieves in a Ro-Tap Shaker (Laval Lab Inc., Laval, Quebec, Canada). The openings of the sieves were 6.3, 2, 0.71, 0.5, 0.25, and 0.11 mm. Each sample was shaken through the sieve column for five min. Particle size distribution was simplified by grouping the sieve sizes into four categories including extra large (XL), large (L), medium (Med), and fines categories, with

XL >6.3 mm, L between 6.3 and 2 mm, Med between 2 and 0.71 mm, and fines as all materials ≤0.5 mm.

Physical Properties

Physical properties were run on three replications from each of the eight treatments, using NCSU porometers (Fonteno and Harden, 2010) generating values for container capacity (CC), air space (AS), and bulk density (Db). Samples were wet up to 1.5 mass wetness or 66% moisture content prior to testing.

RESULTS AND DISCUSSION

Source 1 had 29% white wood in the fresh bark and 13.4% white wood in the aged bark (Table 1). The high level of white wood in the fresh bark would cause the material to not be considered pine bark by standards of Mulch and Soil Council (MSC), as a bark needs to contain no more than 15% white wood. However, the Source 1 supplier does not sell fresh bark, only aged. The particle size distribution for Source 1 shows a high level of XL and L particles in the fresh bark, with the aged bark having fewer XL and L particles and more fines. This is as expected as the aging process tends to break down particles and create more fines. Total porosity (TP) values for Source 1 bark were the same for fresh and aged bark, between 80 and 82%, however, container capacity for the fresh was 49% and increased to 62% for aged (Table 2). This showed a significant and typical increase in water holding ability as the bark aged. The Best Management Practices range for CC in pine bark substrate is from 45 to 65%. The AS values were typically higher for the fresh (33.8) and lower for the aged (17.9), as an increase in CC results in a decrease in AS when TP remains the same.

Source 2 had 11.4% white wood in the fresh bark and 4.4% white wood in the aged bark (Table 1). These numbers are very desirable values for white wood. In contrast with Source 1 these values are much lower, which may be attributed to the manufacturing process. The difference in processing between Source 1 and 2 could account for the differences in white wood for the fresh. Source 2 has a higher percentage of XL and L particles in the fresh bark. The aged bark has increased fines with lower percentages of XL and L particles. These are desirable values and are similar to that of Source 1. Source 2 had a TP value of 82% which is similar to Source 1 (Table 2). The CC values however were 34% for the fresh and 50% for the aged bark. The CC value for the aged bark is in the acceptable range for CC according to BMPs, however the fresh bark is not. When compared to the bark from Source 1, these CC values were much lower. The aged bark from Source 2 had the same CC as the fresh bark from Source 1. Both aged materials do meet BMP standards; however the range for BMPs is wide and Source 1 aged is at the high end of the range while Source 2 aged is at the low end of the range. The fresh pine bark from Source 2, which is a commercial product does not meet BMP standards, while the fresh bark from Source 1 (not a commercial product), does meet BMP standards.

Bark from Source 1 held significantly more water than bark from Source 2 (Table 2). This is likely due to lack of irrigation while bark is piled in windrows at Source 2. Source 1 irrigates their piled bark, keeping the moisture content above 40%, while Source 2 does not irrigate bark. Bark from Source 1 had moisture contents between 44 and 48% at the time the sample was collected, while bark from Source two had moisture contents between 32 and 35%. Pine bark has been shown to become hydrophobic when allowed to dry out to a moisture content below 34% by volume (Airhart, 1978; Pokorny, 1979). This can be why the bark from Source 2 does not hold nearly as much water as bark from Source 1, and would require a grower to irrigate more frequently or use amendments to increase CC.

Physical properties did not change significantly after the removal of white wood from any of the bark samples. Removing the white wood (29%) from the fresh bark from Source 1 did cause the CC to rise, however it was not significantly greater. Therefore the white wood was not shown to be deleterious to the physical properties of the barks.

Table 1. Particle size distribution and wood content of fresh and aged pine bark from two different sources.

Parameter	Source 1		Source 2	
	Fresh	Aged	Fresh	Aged
	(%)			
Extra large[z]	22.7 a[y]	10 b	18.9 a	14.7 b
Large[x]	46 ab	40.4 bc	51.1 a	39.3 c
Medium[w]	20.5 c	26.7 a	17 c	22.4 b
Fines[v]	10.8 b	22.9 a	7.6 b	22.4 a
White wood[u]	29.25 a	13.4 b	11.4 b	4.4 c

[u]Percentage of white wood in pine bark by mass.
[v]Particles smaller than 0.71 mm.
[w]Particles between 0.71 mm and 2 mm.
[x]Particles between 2 mm and 6.3 mm.
[y]Statistics were done using Tukey HSD with α=0.05, preformed across rows.
[z]Particles larger than 6.3 mm.

Table 2. Physical properties of fresh and aged pine bark with and without white wood.[z]

	TP[y] (%Vol)	CC[x] (% Vol)	AS[w] (%Vol)	Db[v] (g/cc)
Pine bark[u]				
Source 1 fresh	81.92 a	48.54 bc	33.8 bc	0.19 a
Source 1 aged	80.02 a	62.09 a	17.94 d	0.19 a
Source 2 fresh	82.47 a	33.74 d	48.73 a	0.18 a
Source 2 aged	82.83 a	49.55 bc	33.29 bc	0.19 a
Pine bark no wood[t]				
Source 1 fresh	80.38 a	56 ab	24.36 cd	0.19 a
Source 1 aged	80.68 a	60.45 a	20.14 d	0.19 a
Source 2 fresh	77.3 a	35.87 d	41.43 ab	0.19 a
Source 2 aged	79.7 a	46.43 c	33.37 bc	0.18 a

[t]Pine Bark with after removal of white wood.
[u]Unseperated samples.
[v]Bulk density is dry weight/total volume of sample.
[w]Air space is unoccupied space at CC (TP-CC).
[x]Container capacity is pore space occupied by water (TP-AS).
[y]Total porosity is equal to total pore space (CC + AS).
[z]Analysis performed using NCSU porometer.

SUMMARY

Judging the properties of bark visually can be challenging The aged bark from both sources looked to have desirable properties for growth, yet Source 1 had more than twice the percentage of white wood than Source 2. However, after testing the bark from Source 2, while meeting BMP standards, holds much less water than Source 1. This does not mean that this bark cannot be used to grow a healthy crop; however, more water would be needed to produce a crop grown in bark from Source 2 than Source 1.

The white wood content decreased by more than half as each bark was aged. The particle size distribution (Table 1) also changed significantly from fresh to aged pine bark. Often growers look at particle size distributions as an indicator of how a substrate will perform, however this research did not show this. The two bark sources had similar PSD, while their water holding abilities differed greatly.

White wood percentages ranged from 4.4% by weight in Source 2 aged to 29% by weight in Source 1 Fresh. However, no significant change was seen in any physical property after the removal of white wood. The bulk density of the white wood itself is lower than that of the bark, about 0.14 $g \cdot cm^{-3}$. This means that the addition of white wood may lower the weight of pine bark without altering other physical properties. Although the wood content in the Source 1 fresh was well above industry standards, it had no affect on physical performance. In fact, the complete removal of white wood did not alter physical properties at all in any of the barks tested in this experiment.

Literature Cited

Airhart, D.L., Natarella, N.J. and Pokorny, F.A. 1978. The structure of processed pine park. J. Amer. Soc. Hort. Sci. 103:404-408.

Airhart, D.L., Natarella, N.J. and Pokorny, F.A. 1978. Influence of initial moisture content on the wettability of a milled pine bark medium. HortScience 13:432-434.

Bilderback, T.E., Warren, S.L., Owen, J.S. and Albano, J.P. 2005. Healthy substrates need physicals too! HortTechnology 15:747-751.

Cobb and Keever. 1984. Effects of supplemental N on plant growth in fresh and aged pine bark. HortScience 19:127-129.

Fonteno, W.C. and Harden, C.T. 2010. Procedures for determining physical properties of horticultural substrates using the NCSU Porometer. Horticultural Substrates Lab, North Carolina State University.

Hanan, J.J. 1998. Greenhouses: Advanced Technology for Protected Horticulture. CRC Press.

Handreck, K.A. and Black, N.D. 1994. Growing Media for Ornamental Plants and Turf. Univ. New South Wales Press, Randwick, Aust.

Harrelson, T., Warren, S.L. and Bilderback, T.E. 2004. How do you manage aged versus fresh pine bark? Proc. SNA Res. Conf. 49:63-65.

Laiche, A.J. 1974. Pine bark growing media-fertility studies for the production of container-grown ornamentals. MAFES Res. Highlights. 37:1-3.

Mulch and Soil Council. 2007. Voluntary uniform product guidelines for horticultural mulches, growing media and landscape soils. Version 8.0. www. mulchandsoilcouncil.org.

Nelson, P.V. 2011. Greenhouse Operation and Management. 7th ed. Prentice Hall

Pokorny, F.A. 1979. Pine bark container media – An overview. Comb. Proc. Intl. Plant Prop. Soc. 29:484-495.

Pokorny, F.A. 1975. A physical characterization of pine bark used in six commercial nurseries. SNA Res. Conf. 20:25-27.

Self, R.L. and Pounders, C.T. 1974. Comparison of sulfur-coated urea and nitroform in potting soils. Proc. SNA Res. Conf. 19:22-23.

Solbraa, K. 1974. Composting of bark. Proc. Symp. West-European Working Group on the Standardization of Bark Compost in Horticulture. Ghent, 10-14:39-85.

Yeager, T.H., Fare, D.C., Lea-Cox, J., Ruter, J., Bilderback, T.E., Gilliam, C.H., Niemiera, A.X., Warren, S.L., Whitwell, T.E., Wright, R.D. and Tilt, K.M. 2007. Best Management Practices: Guide for Producing Container-Grown Plants. 2nd ed. Southern Nurserymen's Assoc., Marietta, Georgia.